



Forest Sciences

Prince Rupert Forest Region

Extension Note # 28

December, 1997

Site Preparation Alternatives to Broadcast Burning

Research Issue Groups:

Forest Biology

Forest Growth

Soils

Wildlife Habitat

Silviculture

Timber Harvesting

Ecosystem Inventory and
Classification

Biodiversity

Ecosystem Management

Hydrology

Geomorphology

Extension

Introduction

Broadcast burning for site preparation has been an effective tool for foresters, but its use has declined substantially in recent years due to concerns over air quality and the increasing costs and risks compared to mechanical treatments. Two of the more common alternatives to broadcast burning in the north-central interior of B.C. have been disc trenching and windrow piling. We do not fully understand the costs and benefits, in terms of short- and long-term site productivity, of this shift away from broadcast burning to mechanical treatments.

This note describes and compares the soil properties of various microsites created by broadcast burning, disc trenching, piling and burning, and no-site-preparation treatments (control). In addition, the levels of soil disturbance associated with the treatments and the survival and growth of planted lodgepole pine and white spruce are examined.

Together, these short-term results will help to illustrate some of the soil and silvicultural costs and benefits of common site preparation alternatives

for the north-central interior of B.C.

Study Site

The study is located on a mesic site, with a gently sloping (0-5%) north aspect, transitional between the SBSmc and ESSFmc subzones (elevation 1000m), 50 km NE of Smithers in the Bulkley Forest District. The study site has well to moderately-well drained soils of loam to silty clay loam texture, a variable coarse fragment content (0-60% volume) and 3-8 cm of forest floor (hemimor). Growing seasons in the area are short and relatively moist and cool, and are followed by cold, snowy winters. Low soil temperatures persist well into the growing season (May/June) and can be considered a major growth-limiting factor on the site. Frost can occur any month of the year, however the site does not appear to be subject to cold-air ponding.

Four site preparation treatments were carried out in 1992:

Broadcast burn

A 12-ha portion of the block was successfully broadcast burned while the soils and larger fuels were still

very moist in June, 1992. The burn removed a high percentage of the fine slash while forest floor consumption averaged 1 cm.

Disc trenching

A TIS Delta power disc trencher mounted on a rubber-tired skidder was used. The skidder had a brush blade mounted on the front to deflect slash from the rear discs.

Pile and burn treatment

Slash was piled into 60-metre-long windrows, 1m in height, with a Cat-180 excavator fitted with a brush rake. Windrows were burned in late October, resulting in patchy consumption of fuels.

No treatment (control)

Three plots with no site preparation were planted for comparative purposes. This treatment is

characterized by intact forest floors and widespread deposits of logging slash.

Effects of site preparation treatments on microsite properties

Some of the site preparation treatments resulted in significant changes to important soil physical and chemical properties which influence seedling establishment and growth (Table 1). In some cases, such as the disc trenching and pile and burn treatments, these properties represent what a seedling might experience at the planting spot, rather than characterizing the soil of the entire treatment area.

The following discussion lists a few of the important microsite properties influenced by the site preparation treatments.

Bulk density

Soils with low bulk density are usually loose and well aerated, which promotes root growth and improves soil processes such as drainage and gas exchange. Disc trenching reduced the soil bulk density on the berm and hinge microsites because the treatment mixed organic matter from the forest floor with the mineral soil. Bulk densities were reduced by approximately 35% for the berm microsite compared to the untreated soil. Trench microsite and windrow treatments had higher bulk density values, although variability was extremely high among these microsites, which reduced statistical significance. Changes in bulk density are likely due to compaction from the excavator operating on moist soils. The compaction from the excavator was more extreme in the tracks, but even the less disturbed

Table 1. Average soil properties for treatment microsites (2 years after treatment).

Site preparation technique	Bulk density	Heat sum ²	Frost events		moisture	Min N	Avail P	exch K	Shrubs	Herbs
	2 to 7 cm (g/cm ³)	(° days)	May 16 th to July 31 st (<0°)	(<-4°)	% time wet ³	(ppm)	0-20 mineral (ppm)	meq/100g	Treatment area ⁴ (% cover)	
No treatment	1.13bcd ¹	740	26	3	100	17.7d	25.2b	0.22d	10	45
Broadcast burn	1.11bd	851	12	0	88	14.5cd	37.4a	0.22d	< 5	25
Disc-trench berm	0.72a	1051	10	0	25	38.1a	38.6a	0.44a	< 5	60
hinge	0.85ab	920	2	0	63	30.8b	26.4b	0.28c		
trench	1.35c	878	1	0	75	11.7c	13.9c	0.18d		
Windrow burned pile	n/a	856	17	0	100	18.8d	23.1bc	0.34b	< 5	65
between piles	1.26cd	828	n/a	n/a	88	19.3d	23.6bc	0.28c		
excavator track	1.35cd	n/a				n/a				

¹ Means followed by the same letter are not significantly different ($p < 0.05$) using Tukey's multiple range test.

² Microclimate monitoring was on one plot per treatment only, so no statistical analysis was attempted.

³ % time 'wet' refers to the percent of the time period where soil moisture was near saturation (0-0.33 bars).

⁴ Vegetation cover was determined in year 5.

soils around the windrows had somewhat higher bulk densities than untreated soils. The higher bulk density on the trench microsite could be due to naturally dense soil horizons. This microsite is lower in the soil profile (15 cm depth), which is sometimes more dense and clay-rich than upper horizons.

Microclimate

Low soil temperatures can limit seedling growth in the central interior, so the extent to which a site preparation treatment increases growing season soil temperatures is an important factor in improving seedling vigor. The relative microclimate of the soil can be expressed by 'growing degree days', which is the sum of average daily soil temperatures (10 cm depth) above 0° C. Growing degree days show a trend of increasing soil warming with disc trenching and burning treatments compared to the control treatment. Disc trenching increases soil warming at the berm and hinge microsite by removing the insulating organic layers, increasing the surface area of the microsite, and reducing the moisture content of the soil. These changes allow better conductance of heat energy into the soil. Since wet soils require more energy to heat than drier soils, the improved drainage also contributes to higher heat sums for this microsite. The disc trench berm had the highest heat sum of the treatments, with an increase of approximately 40% compared to no site preparation.

Burning blackens the soil surface, which decreases the albedo (surface

reflectivity) of the surface soil, improving the rate of absorption of heat energy. This effect, along with the removal of insulative slash, explains the increase in soil warming for the broadcast burn and windrow pile microsites.

Frost events are common in any month of the year in both the ESSFmc and SBSmc subzone, particularly at elevations above 1000 m. Reducing frost events through site preparation can help to decrease mortality and damage to seedlings. Generally, the control treatment was found to be more susceptible to frost damage, and was the only treatment susceptible to severe frosts (air temp. < -4°C). The disc trenching and burning treatments increased the amount of heat energy stored in the mineral soil, which can help to offset the loss of heat at night from the ground surface.

Soil moisture remained at field capacity for most of the growing season throughout the study area, so the limitation of growth due to moisture stress seems unlikely. Excess soil moisture could be a more serious limitation to seedling growth in this ecosystem, so treatments that improve drainage should be particularly beneficial. During the first two months of the growing season, the untreated soils were close to saturation at all times. The raised, loose berm microsite formed by the disc trenching treatment resulted in greatly improved drainage. Broadcast burning tended towards lower levels of soil moisture than the controls, which may be a result of higher levels of evaporation. The

removal of slash and decreased forest floor thickness and the better absorption of radiation by the blackened surface contribute to more evaporation.

Soil nutrients

Site preparation treatments can increase the availability of nutrients for seedlings by releasing nutrients bound in organic matter, through burning or increased rates of decomposition. Table 1 includes three important nutrients to illustrate some of the changes in nutrient availability following site preparation. Burning of organic matter usually releases cations such as potassium, as demonstrated by higher K concentrations under the burned windrow piles. The availability of phosphorus often increases after burning due to the increased soil pH. This is seen in the broadcast burn treatment, but was not apparent in the windrow piles. Burning also volatilizes nutrients such as nitrogen and sulphur which, if losses are large enough, can reduce long-term nutrient supplies for the plantation.

The mixing of organic matter with mineral soil will often accelerate the rate of decomposition and increase the availability of nutrients in the soil. The berm microsites for the disc trenching treatment consistently increased the mineralizable nitrogen, phosphorus and potassium compared to control treatments. The trench microsite had the poorest nutrient availability because of the displacement of surface mineral soil and forest floor layers and exposure of nutrient-poor subsoil.

Vegetation competition

High levels of vegetation competition can hinder seedling establishment and growth, so vegetation control is often one of the goals of site preparation. Initially, this study site had low levels of shrub and herb cover, averaging about 5% and 32%, respectively, on the no-site-preparation treatment. By year 5, however, a large amount of grass and forbs had colonized the disturbed soil on the disc trenching and windrowing treatments, increasing the total cover to higher levels than those of the broadcast burn and control treatments.

Vegetation cover can help ameliorate frost events, but at this site the increased vegetation cover, especially grass, is likely affecting seedling growth through competition.

Site Disturbance Surveys

The procedure for assessing site sensitivity and soil disturbance following harvesting and site preparation has undergone several changes during the past few years. The information collected at this study site used the disturbance categories and definitions from 1991:

L - light machine traffic

<5 cm impression into the mineral soil

1 - heavy machine traffic

5 to 10 cm impression into the mineral soil

G - deep gouge

> 30 cm deep at the survey point

D - deposit

deposits of organic/slash/mineral material including piles > 33% mineral soil (minimum mineral soil

Table 2. Percent soil disturbance caused by site preparation techniques.

Site Preparation Technique	Soil Disturbance Class (% of treatment area)					
	L	1	G	O	D	U
Disc trench						
postharvest	9.7	1.3	0	12.4	0	76.3
after site prep	13.6	0	0.1	15.4	33.5	25.4
change	3.9	-1.3	0.1	3.0	33.5	-50.9
Pile-and-burn						
postharvest	10.3	4.2	0	13.1	0	75.8
after site prep	38.8	2.5	0	10.7	11.8	36.1
change	28.4	-1.7	0	-2.4	11.8	-39.7
Broadcast burn						
postharvest	6.1	0.4	0	11.8	0	81.7
No treatment						
postharvest	12.4	0.1	0	8.8	0	78.8

deposit depth is 3 cm, organic material depth 15 cm)

U - undisturbed

undisturbed soil, forest floor intact

O - other disturbance

disturbances not described by other classes

Table 2 presents the results of soil disturbance surveys before and after site preparation. Prior to treatments there was light soil disturbance caused by skidder and feller-buncher traffic over 9.6% of the area, on average. This disturbance likely occurred as the snowpack subsided during logging, reducing the protection of the soil from machine traffic.

Among site preparation treatments, the pile and burn treatment resulted in the highest levels of soil disturbance: an additional 28% of the area sustained a level of disturbance rated as 'lightly disturbed'. In comparison, disc trenching lightly

disturbed only an additional 3.9% of the area. Although light disturbance is not currently categorized as detrimental soil disturbance, there is potential for productivity loss from 'light' compaction with damage to surface soil structure, decreased porosity and infiltration rates on medium- to fine-textured soil. It was relatively common to find water ponding in excavator tracks, even though track impressions were generally less than 5 cm in depth.

Seedling survival and growth

Seedling survival can be affected by factors such as vegetation competition or frost events. One of the goals of site preparation is to alter conditions so that seedling survival and growth are improved. On this site, however, most (>90%) of the planted seedlings survived regardless of treatment. The third and fifth year seedling growth response shows consistently good growth for broadcast burn

treatments, followed by disc trenching, pile and burn and then no-site-preparation treatments (Figure 1). These trends reflect the changes in soil properties brought on by site preparation. Broadcast burning and disc trenching improved soil warming, drainage and nutrient release, but higher vegetation competition could be affecting seedling growth in the disc trench treatment. Pile-and-burn treatments had poorer seedling growth, which might also be attributed to higher vegetation competition and the increases in soil bulk density from compaction. The colder, wetter microsites of the untreated plots lead to the poorest seedling growth, which illustrates the benefits of some form of site preparation.

Conclusions

This study examined alternatives to broadcast burning from a soils point-of-view. Many of the other costs and risks of forest management are outside the scope of this discussion. From this perspective, the study results show how effective broadcast burning can be in plantation establishment and growth. The improvement in soil properties, reduction in vegetation competition, and increased seedling growth emphasize the usefulness of this treatment.

Of the alternative site preparation treatments examined, the disc trench berm microsite initially had the most favorable combination of soil properties for seedling growth. The mixing of the mineral soil and forest

floor resulted in a raised microsite with a lower bulk density, improved drainage, increased warmth, and increased nutrient availability. The advantages for the berm microsite could be short-term, however, because tree roots will extend past the berm into the less favorable, untreated soil between trenches.

In most disc trenching treatments for the central and northern interior, the hinge position is selected for planting because the berm often becomes too dry during the summer. In cool, moist climates such as our relatively high-elevation study site, there is a much lower risk of moisture limitations, so the berm microsite would be recommended for planting in preference to the hinge. Trench microsites should not be regarded as

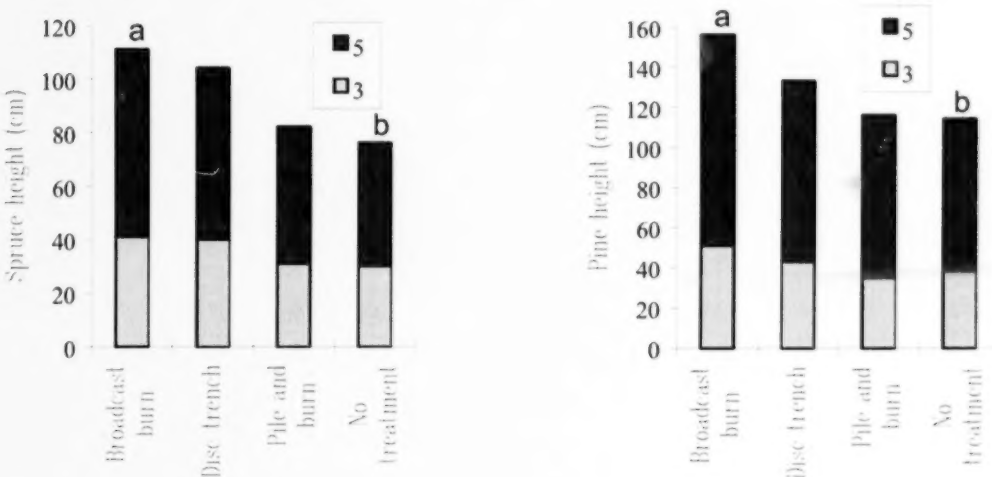


Figure 1. White spruce and lodgepole pine growth at years 3 and 5. Columns labelled with letters are significantly different ($p < 0.05$).

acceptable planting spots on these sites.

The pile and burn treatments were effective in improving some soil properties such as soil warming and nutrient availability. However, this study showed that pile and burn treatments are more likely to cause unwanted soil disturbance. Some types of soil disturbance classified as 'light' (i.e. < 5 cm impression into mineral soil) could still negatively affect seedling growth. In addition, the pile and burn treatment can reduce the natural distribution of coarse woody debris across the site, with unknown ecological consequences. Of the site preparation treatments examined, the pile and burn treatment has the largest risk to long-term site productivity and the smallest return in microsite enhancement.

Doing no site preparation is certainly a viable option, and is currently the prevailing "treatment" in the Prince Rupert Forest Region. The high seedling survival in this study demonstrates that plantation establishment is less difficult with current nursery stock. Untreated sites have reduced seedling growth rates (at least initially), so forest managers must weigh the risks and costs of treatment against the potential early gains in stand productivity.

This project was undertaken by Dave Yole, Anne Macadam and Marty Kranabetter. More information on methodology and treatment response is contained in the second year progress report, Ministry of Forests (Smithers) Regional Forest Sciences Section.